

What Is Claimed Is:

1. A device for fixing a flexible elongated element to a portion of a subject, said device comprising:

structure for retaining the flexible elongated element;

advancement means for longitudinally advancing the flexible elongated element from a proximal end of said device toward a distal end of said device with sufficient force to pass the element through the portion of the subject; and

securing means for securing the element to the subject and for variably adjusting a securing force applied by the flexible elongated element to the portion of the subject.

2. The device as claimed in claim 1, wherein a longitudinal axis extends between said proximal and distal ends of said device, and wherein said securing means include a rotation unit for rotating said distal end of said device about said longitudinal axis.

3. The device as claimed in claim 1, wherein said distal end of said device includes at least one adjustable jaw for gripping the portion of the subject between opposing jaw surfaces.

4. The device as claimed in claim 1, wherein said advancement means include at least one drive wheel for contacting said flexible elongated element, and guide means for permitting said flexible elongated element to move only in a direction corresponding to a longitudinal axis of said flexible elongated element.

5. The device as claimed in claim 1, wherein said device further includes a cutting unit for selectively cutting a portion of a distal end of said flexible elongated element.

6. A device for use in passing a flexible elongated element through at least two portions of a subject, said device comprising:

a hollow wire guide for guiding the flexible elongated element through said device toward a distal end of said device and toward the subject;

at least one drive unit for urging the elongated element toward said distal end of said device through said hollow wire guide, and passing the elongated element through the at least two portions of the subject; and

securing means for variably adjusting a securing force applied by the flexible elongated element to the at least two portions of the subject, so as to secure together the at least two portions of the subject with a selected force.

7. The device as claimed in claim 6, wherein said device further includes a longitudinal axis extending between a proximal end and said distal end of said device, and wherein said securing means include a rotation unit for rotating said distal end of said device about said longitudinal axis.

8. The device as claimed in claim 6, wherein said distal end of said device includes at least one

adjustable jaw for gripping the at least two portions of the subject between opposing jaw surfaces.

9. The device as claimed in claim 6, wherein said advancement means include at least one drive wheel for contacting said flexible elongated element, and further wherein said hollow wire guide is adapted to permit said flexible elongated element to move only in a direction corresponding to a longitudinal axis of said flexible elongated element.

10. The device as claimed in claim 6, wherein said device further includes a cutting unit for selectively cutting a portion of a distal end of said flexible elongated element.

11. Apparatus for joining two segments at a surgical site, said apparatus comprising:

a flexible elongated element including a first portion and a second portion;

means for advancing said first portion of said flexible elongated element through each of a first segment and a second segment; and

means for joining said first portion of said flexible elongated element with said second portion of said flexible elongated element such that the joiner is variably adjustable, whereby each of said first and second segments are maintained in selected proximity to one another.

12. Apparatus as claimed in claim 11, wherein said flexible elongated element further includes a third portion, and said apparatus further includes means for cutting said flexible elongated element at a location between said second and third portions of said flexible elongated element.

13. A system for providing controlled movement of a flexible elongated element within a medical instrument, said system comprising:

support means mounted in the medical instrument for axially surrounding the flexible elongated element, said support means including at least one opening; and

drive means mounted in the medical instrument for contacting the flexible elongated element through said opening so as to urge said flexible elongated element

to move longitudinally within said support means, said support means serving to inhibit lateral movement of said flexible elongated element.

14. A system as claimed in claim 13, wherein said system further includes rotation means for rotating a distal end of said device.

15. A suturing instrument for joining portions of a subject during a medical procedure, said device comprising:

a proximal end, a distal end, and a longitudinal axis extending between said proximal and distal ends, said distal end including an opening;

a flexible elongated element extending along said longitudinal axis toward said distal end;

guide means for restricting the movement of said flexible elongated element in directions other than along said longitudinal axis; and

advancement means for advancing said flexible elongated element along said longitudinal axis toward said distal end of said device.

16. A method of applying sutures with a suturing instrument, said method comprising the steps of:

advancing a suture material along a longitudinal axis of the suturing instrument toward a distal end thereof;

forcing the suture material through a subject to be sutured at the distal end of the suturing instrument;

twisting together a free end of the suture material extending from the subject and a remaining portion of the suture material so as to lock the free end of the suture material to the remaining portion of the suture material.

17. The method as claimed in claim 16, wherein said method further includes the step of severing the twisted suture material from the suture material within the suturing instrument.

18. A device for fixing a wire in tissue, the device comprising:

support structure for retaining the wire;

advancement apparatus for advancing the wire through said support structure and out a distal end portion of said support structure with sufficient force to drive a distal end portion of the wire through the tissue;

receiving structure for receiving and retaining the distal end portion of the wire; and

rotation apparatus for twisting together the distal end portion of the wire and a further portion of the wire adjacent to the distal end portion of the wire, so as to adjustably fix the wire to the tissue.

19. A device according to claim 18 further comprising a severing device for severing the further portion of the wire from a remainder of the wire.

20. A device according to claim 18 further comprising control structure on said device for selectively determining the degree of twisting of said distal end portion of the wire and said further portion of the wire.

21. A device for fixing a wire in tissue, the device comprising:

support structure for retaining the wire;

opposed gripper members at a distal end of said device for gripping the tissue therebetween;

advancement apparatus for advancing the wire through said support structure and out a distal portion of a first of said gripper members with sufficient force to drive a distal end portion of the wire through the tissue and into a receiving cavity in a distal end portion of a second of said grippers; and

rotation apparatus for rotating said gripper members about an axis for twisting together said distal end portion of the wire and a further portion of the wire adjacent the distal end portion of the wire, so as to adjustably fix the wire to the tissue.

22. An assembly for suturing together first and second portions of tissue, the assembly comprising:

a wire suture element, said wire suture element being of such flexibility as to (1) bend if not supported along a length thereof, and (2) twist upon

itself and not deform tissue in which said wire suture element is disposed;

support structure for retaining said wire suture element along a selected path;

opposed gripper members fixed to a distal end of said support structure for gripping the tissue portions therebetween, said gripper members having opposed channels therein for receiving said wire suture element, said channels being generally normal to a lengthwise axis of said support structure;

advancement apparatus for advancing the wire suture element through said support structure, through the channel in a first of said gripper members, through the tissue portions, and into the channel in a second of said gripper members; and

rotation apparatus for rotating said gripper members around the lengthwise axis of said support structure for twisting together first and second portions of the wire suture element adjacent to the tissue, whereby to variably join together the two wire suture element portions and thereby suture together the first and second portions of tissue.

23. An assembly according to claim 22 further comprising a handle proximate a proximal end of said assembly, and wherein said support structure comprises an elongated tube extending between said handle and said gripper members, such that said gripper members are sufficiently spaced from said handle to facilitate disposition and operation of said gripper members within a mammalian body while said handle is disposed outside of said mammalian body, for control of said gripper members and said wire suture element from outside of said mammalian body.

24. A suture supply cartridge for a suture tool, the tool comprising a housing, an elongated tube extending from the housing, an advancement apparatus for advancing a suture distally through the tube, and a control actuator mounted on the housing for selective operation of the suture advancement apparatus, the suture supply cartridge comprising:

a cartridge housing adapted for attachment to the tool;

a wall disposed in said cartridge housing and, in cooperation with said cartridge housing, defining a chamber for storage of the suture;

a wire guide support having a base portion fixed to said wall, and having a protrusion portion extending distally from said base portion, said base portion and said protrusion portion defining a bore extending axially therethrough, said protrusion portion having openings in side walls thereof; and

an elongated suture guide fixed in said wire guide support and extending distally therefrom, said suture guide having openings in side walls thereof aligned with said protrusion openings, the suture extending through said suture guide;

said suture wire guide protrusion openings being adapted to receive drive wheel portions of the tool advancement apparatus upon connection of said cartridge housing to said tool, such that said drive wheel portions extend through said suture guide openings to engage the suture.

25. A method for suturing first and second tissue portions, the method comprising:

holding an edge of the first tissue portion adjacent to an edge of the second tissue portion;

driving a strand of suture material through the first and second tissue portions proximate to the tissue portion edges, a portion of the strand exiting the second tissue portion;

twisting together the exited portion of the strand and a portion of the strand adjacent to a suture entry location on the first tissue portion; and

severing the suture to separate the twisted-together portions of the strand from a remainder of the suture strand.

26. A method according to claim 25, further comprising an initial step of selecting the strand of suture material exhibiting such flexibility as to

- (1) bend if not supported along a length thereof, and
- (2) twist upon itself and not deform the tissue into which it is driven.

27. A method according to claim 25 wherein the degree of twisting of the twisted-together portions of the strand is selected so as to provide a selected

tightness of a resulting strand loop extending through the tissue portions.

28. A method according to claim 25 including the step of providing a tool for effecting the method, the tool having a handle portion proximate a proximal portion of the tool and a distal end portion removed from the handle portion by a distance sufficient to enable disposition and operation of the distal end portion of the tool within a mammalian body while the handle portion remains disposed outside of mammalian body, the method further including the steps of inserting the distal end portion of the tool in the mammalian body, locating the distal end portion adjacent to a site for suturing, and operating mechanisms on the handle portion outside of the mammalian body to effect suturing inside the mammalian body.

29. A system for suturing tissue at a surgical site within a mammalian body, the system comprising:

a single instrument for passing a first portion of suture through the tissue and for intertwining the

first portion of suture with a second portion of suture so as to form a joinder of said suture portions at the surgical site, whereby to lock the suture in position relative to the tissue.

30. A system according to claim 29 wherein said single instrument further comprises cutting apparatus for severing said second suture portion from a remaining portion of suture.

31. A suturing device, comprising:

a housing;

a shaft extending distally from said housing;

a pair of opposing jaws located at a distal end of the shaft, said jaws adapted to grasp two elements to be sutured together without piercing the elements; and

a source of suture material located in the housing, the distal end of the suture material extending through the shaft and being adapted to be pushed through the two elements to be sutured together.

32. A suturing device, comprising:

a housing;
a shaft extending distally from said housing;
a pair of opposing jaws located at a distal end of
the shaft;

a source of suture material located in the
housing; and

a motor located in the housing for rotating the
shaft and the jaws about an axis.

33. A suturing device, comprising:

a housing;
a shaft extending distally from said housing;
a pair of opposing jaws located at a distal end of
the shaft;

a source of suture material located in the
housing;

a first motor located in the housing for advancing
the suture material through the shaft, through one of
the jaws, through two elements to be sutured together,
and into the other jaw; and

a second motor located in the housing for rotating
the shaft and the jaws to secure the suture material to
the two elements.

34. The device of claim 33, wherein the suture material comprises a wire.

35. The device of claim 33, further comprising a handle attached to said housing.

36. The device of claim 33, wherein the source of suture material comprises a wire supply cartridge having a length of wire wound thereon.

37. The device of claim 33, further comprising an actuator for opening and closing the jaws.

38. A method for suturing together two separate elements, comprising:

bringing the first element adjacent the second element;

piercing the first and second elements with a length of suture material through the first and second elements, such that a free, distal portion of the suture material extends distally past the second

element and a proximal portion of the suture material extends proximally past the first element; and

twisting together the free distal portion and the proximal portion of the suture material to secure the first and second elements together.

39. The method of claim 38, further comprising severing the twisted portion of the suture material from the remaining suture material.

40. Apparatus for ligating a subject at a surgical site, said apparatus comprising:

a flexible elongated element including a first portion and a second portion;

means for advancing said first portion of said flexible elongated element around the subject; and

means for joining said first portion of said flexible elongated element with said second portion of said flexible elongated element such that the joinder is variably adjustable.

41. Apparatus according to claim 11 wherein said first and second segments comprise two portions of the same structure.

42. Apparatus according to claim 11 wherein said first and second segments comprise two portions of two different structures.

43. The method as claimed in claim 16, wherein said method further comprises the step of operating on the twisted-together free end and remaining portion so as to reduce the tendency to snag on the same.

44. The method as claimed in claim 43 wherein said step of operating on comprises pressing down flat the twisted-together free end of remaining portion.

45. The method as claimed in claim 43 wherein said step of operating on comprises forming a ball with the twisted-together free end and remaining portion.

46. The device as claimed in claim 6 wherein a lubricious material is positioned between said flexible elongated element and said hollow wire guide.

47. The device as claimed in claim 5 wherein said cutting unit is adapted to cut said flexible elongated element so as to form a sharp point on said flexible elongated element.

48. Apparatus as claimed in claim 11, wherein said flexible elongated element is coated with an agent selected from the group consisting of anti-inflammatory agents, anti-coagulant agents, antibiotics, and radioactive agents.

49. Apparatus as claimed in claim 11, wherein said flexible elongated element is formed out of metal.

50. Apparatus as claimed in claim 49, wherein said metal comprises at least one of the group consisting of stainless steel, titanium and tantalum.

51. Apparatus according to claim 11 wherein said means for advancing includes a piezoelectric element.

10044991 124104